

*Working Copy
PA 1428*

*Copy 44
RM SL9116*

*for T.T. Neill memo to E.B.J.
3/22/58 mtd 3/31/58*



NACA

RESEARCH MEMORANDUM

for the

Civil Aeronautics Administration

DITCHING INVESTIGATION OF A $\frac{1}{20}$ -SCALE MODEL OF THE

BOEING STRATOCRUISER AIRPLANE (C-97)

By Lloyd J. Fisher and John O. Windham

Langley Aeronautical Laboratory
Langley Air Force Base, Va.

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
WASHINGTON



NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

for the

Civil Aeronautics Administration

DITCHING INVESTIGATION OF A $\frac{1}{20}$ -SCALE MODEL OF THE

BOEING STRATOCRUISER AIRPLANE (C-97)

By Lloyd J. Fisher and John O. Windham

SUMMARY

An investigation of a $\frac{1}{20}$ -scale dynamically similar model of the Boeing Stratocruiser airplane (C-97) was made to determine the ditching characteristics and proper technique for ditching the airplane. Scale-strength bottoms were used to determine probable damage to the fuselage and the effect of damage on behavior.

The behavior of the model was determined from visual observations, motion-picture records, and time-history deceleration records. Data are presented in a table, photographs, and curves.

It was concluded that the airplane should be ditched at a medium nose-high landing attitude (near 6°) with landing flaps full down. The airplane will probably make a smooth run of medium depth with light spray and may even trim up slightly in the water. The fuselage will probably be damaged and the lower compartment filled with water. In calm water, the maximum longitudinal deceleration will be about 4g and the landing run will be about four fuselage lengths.

INTRODUCTION

At the request of the Civil Aeronautics Administration, an investigation of a model of the Boeing Stratocruiser airplane was made to determine the probable ditching characteristics and proper technique for ditching the airplane. The model was designed so that either a relatively rigid or an approximately scale-strength bottom half of the

fuselage could be used. The tests were made in calm water at the Langley tank no. 2 monorail. A three-view drawing of the airplane is shown in figure 1.

APPARATUS AND PROCEDURE

Description of Model

The $\frac{1}{20}$ -scale model had a wing span of 7.06 feet, a fuselage length of 5.52 feet, and a gross weight of 16.25 pounds. Photographs of the model are shown in figure 2. The model was constructed principally of balsa wood with spruce or mahogany at areas of concentrated stress. Internal ballast was used to obtain scale weight and moments of inertia.

The landing flaps were installed so that they could be held in the down position at approximately scale strength (designed for an estimated failing load of 225 lb/sq ft, full scale). A calibrated thread was fastened between a wing bracket and a corresponding flap bracket so that loads on the flaps greater than the scale design load would cause the thread to break and the flaps to be free to rotate.

The model was constructed so that the bottom half of the fuselage (below the crease line) could be replaced by sections of various strengths. Both relatively rigid and approximately scale-strength sections were employed. The relatively rigid sections simulated a no-damage condition. The ultimate strength of the bottom of the fuselage was not known; therefore, bottom sections of two different scale strengths were used. The scale-strength bottoms were designed and tested to fail under uniformly distributed loads of 8 and 16 pounds per square inch (full scale). These strength values encompass those of similar commercial transport airplanes previously tested and the strength required for internal pressurization of this airplane. The scale-strength sections were used to determine the amount of damage that would occur in a ditching and the effect of damage on behavior. The scale-strength bottoms were made of balsa stringers, cardboard bulkheads, and 0.001-inch aluminum foil skin. One of these bottoms is shown installed on the model in figure 3. Failure of the main landing-gear doors was simulated by removing them.

Test Methods and Equipment

The test methods and equipment used were similar to those used in previous ditching investigations. The model was attached to a launching

carriage on the Langley tank no. 2 monorail at the desired landing attitude with the control surfaces set to hold this attitude in flight. The model was then catapulted into the air and the preset control surfaces kept the model at approximately the desired attitude during the glide from release to landing.

The results of the investigation were obtained from visual observations, motion-picture records, and time-history deceleration records. The decelerations were measured with a single-component accelerometer located in the model slightly forward of the center of gravity of the model. The natural frequency of the accelerometer was 20 cycles per second and it was damped to about 65 percent of the critical damping. The accuracy with which the instrument could be read was estimated at about $\pm \frac{1}{2}\%$.

Test Conditions

All values given refer to the full-scale airplane.

Gross weight.— A gross weight of 130,000 pounds was simulated in the tests.

Location of the center of gravity.— The center of gravity was located at 25 percent of the mean aerodynamic chord and 9 inches above the thrust line of the inboard engines.

Landing attitude.— Ditchings were made at three landing attitudes: 3° (near static), 6° (intermediate), and 9° (near lift-curve stall).

Landing gear.— The tests simulated ditchings with landing gear retracted.

Flaps.— Landing flaps were tested at both full-up and full-down positions. They were rigidly attached for the full-up position and attached at scale strength for the full-down position.

Landing speed.— The landing speeds are listed in table I. They are the speeds computed from power-off lift curves furnished by the manufacturer.

Fuselage conditions.— The model was tested in the following conditions:

- (a) No damage
- (b) Scale-strength bottom installed and main landing-gear doors removed.

RESULTS AND DISCUSSION

A summary of the results of the investigation is presented in table I. The symbols used in the table are defined as follows:

- b ran deeply — a run in which the model traveled through the water partially submerged showing a tendency to dive although the attitude remained near level.
- h ran smoothly — a run in which there was no apparent oscillation about any axis with a settling motion as the forward speed decreased.
- p porpoised slightly — the model undulated about the lateral axis with some part always in contact with the water.
- r oscillated — the model oscillated about the longitudinal axis. This motion decreased as the forward speed decreased.
- u trimmed up in water — the attitude of the model increased immediately after contact with the water.

Typical damage sustained by the scale-strength bottoms is shown in figures 4 and 5. Figures 6, 7, and 8 present longitudinal-deceleration curves as influenced by damage, flap settings, and landing attitude. Figure 7 also presents attitude, horizontal-displacement, and vertical-displacement curves. Sequence photographs of ditchings at various attitudes are shown in figure 9.

Effect of Damage

The curvature of the aft portion of the fuselage bottom (see figs. 1 and 2(b)) caused a suction force in that area on the undamaged model. This force pulled the horizontal tail under water and subjected it to considerable damage. However, this damage had little effect on behavior of the model. The model always trimmed up upon landing and made a run of about 4 to 7 fuselage lengths depending on the landing

speed. (See table I and fig 7.) The maximum decelerations recorded were 2g with flaps down and 3g with flaps up.

When the model was tested with a scale-strength bottom, some damage always occurred. Generally, bottom damage caused the landing runs to be shorter and the decelerations to be greater than for similar conditions without damage, and the tendency of the model to trim up in the water was reduced when bottom damage occurred. (See table I and fig. 7.) The landing runs in calm water were between 3 and 4 fuselage lengths with maximum decelerations of about 4g when damage occurred. Generally, the model made smooth runs at a medium depth in the water. (See fig. 7.) As can be seen in figure 9, the spray was light in these ditchings. There was not a great deal of difference in the amount of damage occurring on the 8- and 16-pound-per-square-inch bottoms. (See figs. 4 and 5.)

These results indicate that in a ditching the fuselage of the airplane will probably be damaged and the lower compartment filled with water. Passengers and crew should, if possible, be assigned stations in the upper compartment prior to ditching. The buoyancy provided by the low wing should cause this airplane to float fairly high in the water.

Effect of Flaps

When the model was tested with full-down flaps, the flaps failed consistently and had no detrimental effect on behavior. Since full-down flaps make possible a substantial decrease in forward speed, thus lessening the possibility of excessive damage, it is best that the flaps be full down in a ditching.

Effect of Landing Attitude

The effect of landing attitude was most apparent in the amount of damage to the scale-strength bottoms. (See figs. 4 and 5.) The greatest damage occurred at the 3° attitude, probably because of the higher landing speed. Longitudinal decelerations were about the same at all attitudes.

Since the most damage occurred in the 3° landings, a low attitude should be avoided. The tests indicated very little difference in behavior between the 6° and 9° attitude landings, but, because of better flight control, a medium nose-high attitude (near 6°) would probably be better in a ditching than a near-stall attitude.

CONCLUSIONS

From the results of an investigation of a $\frac{1}{20}$ -scale dynamically similar model of the Boeing Stratocruiser airplane (C-97) the following conclusions may be drawn:

1. The airplane should be ditched at a medium nose-high landing attitude (near 6°) with flaps full down.
2. The airplane will probably make a smooth run of medium depth with light spray and may even trim up slightly in the water.
3. The fuselage will probably be damaged and the lower compartment filled with water.
4. When the airplane is ditched as recommended, the maximum longitudinal deceleration in calm water will be about $4g$ and the landing run will be about four fuselage lengths.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Air Force Base, Va.

Lloyd J. Fisher
Lloyd J. Fisher

Aeronautical Research Scientist

John O. Windham
John O. Windham
Aeronautical Engineer

Approved:

John B. Parkinson
John B. Parkinson
Chief of Hydrodynamics Division

TABLE I
SUMMARY OF RESULTS OF DITCHING INVESTIGATION IN CALM WATER OF
A $\frac{1}{20}$ -SCALE MODEL OF THE BOEING STRATOCRUISER AIRPLANE

[Gross weight, 130,000 lb; all values are full scale]

Configuration	Behavior Flap Setting	9						6			3		
		149			112			118			126		
		Maximum longitudinal deceleration (g)	Length of landing runs (ft)	Motions of the model (a)	Maximum longitudinal deceleration (g)	Length of landing runs (ft)	Motions of the model (a)	Maximum longitudinal deceleration (g)	Length of landing runs (ft)	Motions of the model (a)	Maximum longitudinal deceleration (g)	Length of landing runs (ft)	Motions of the model (a)
Undamaged	Up	3	780	up									
	Down				2	460	ur	2	520	uh	2	640	u
Scale-strength bottom installed (8 psi) wheel doors removed	Down				4	360	bh	4	380	ph	3	400	h
Scale-strength bottom installed (16 psi) wheel doors removed	Down				4	400	bh	4	480	uh	4	490	uh

^aMotions of the model denoted by following symbols:

- b ran deeply
- h ran smoothly
- p porpoised slightly
- r oscillated about longitudinal axis
- u trimmed up in water

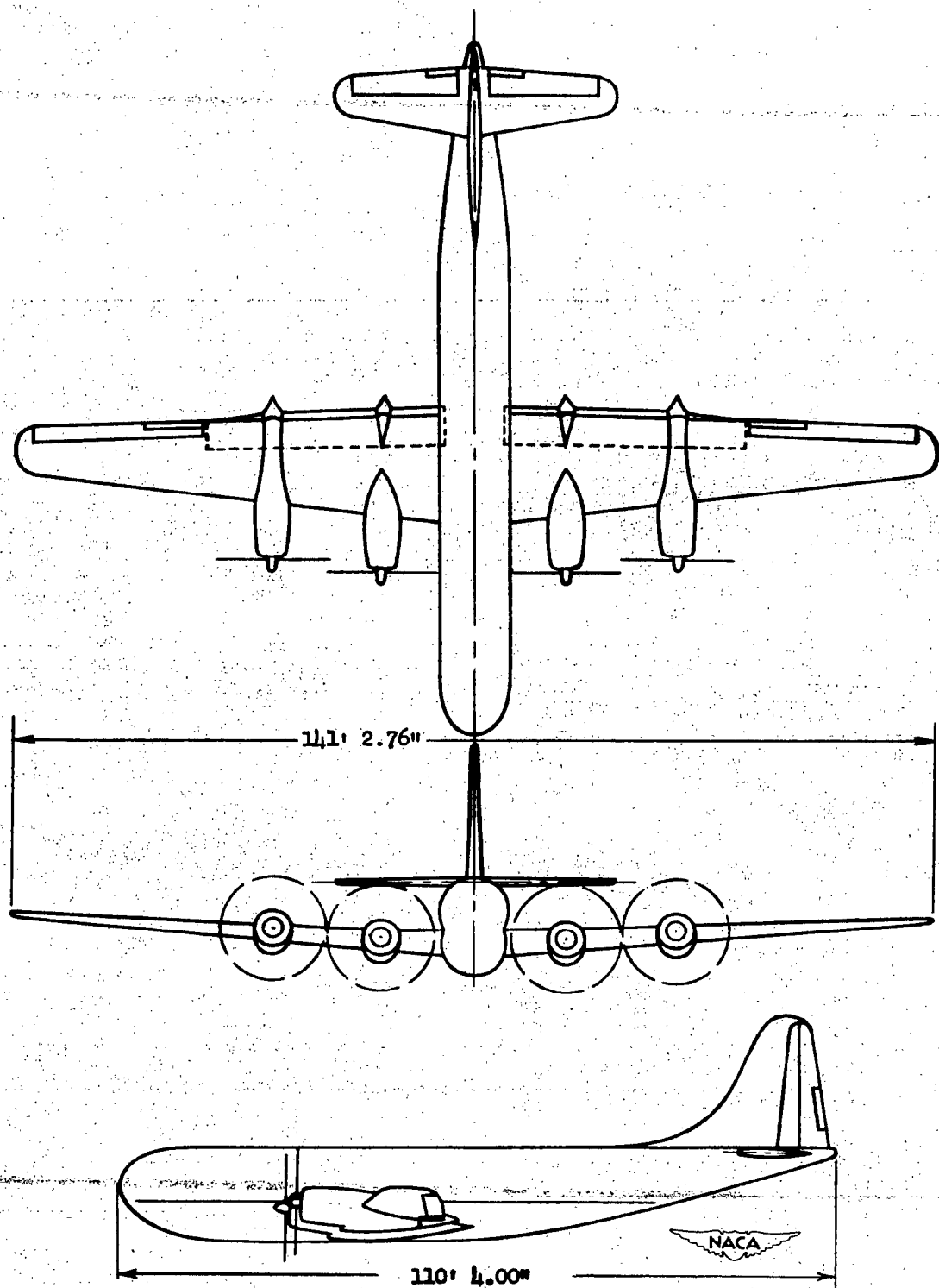
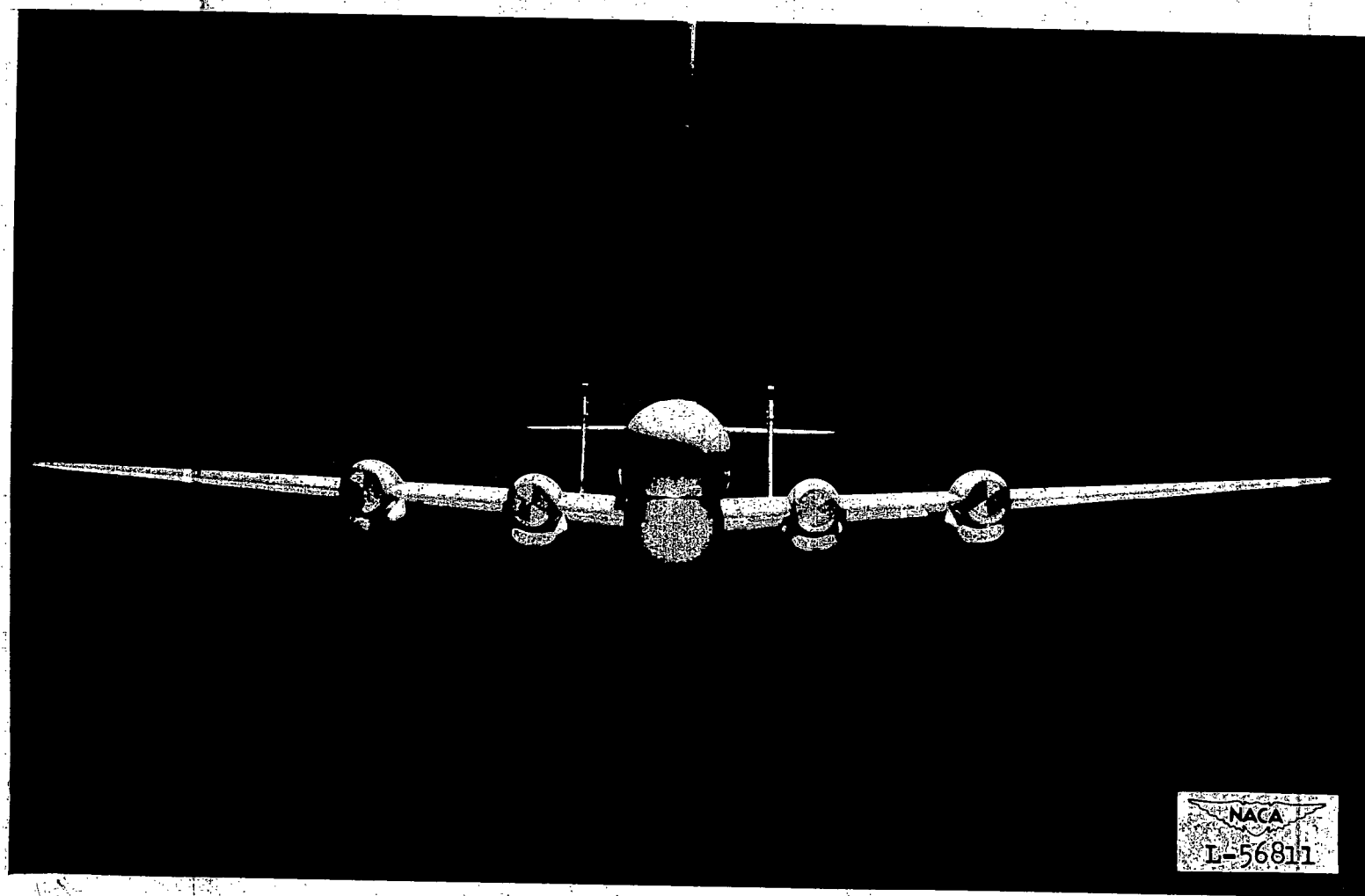


Figure 1.- Three-view drawing of the Boeing Stratocruiser airplane.

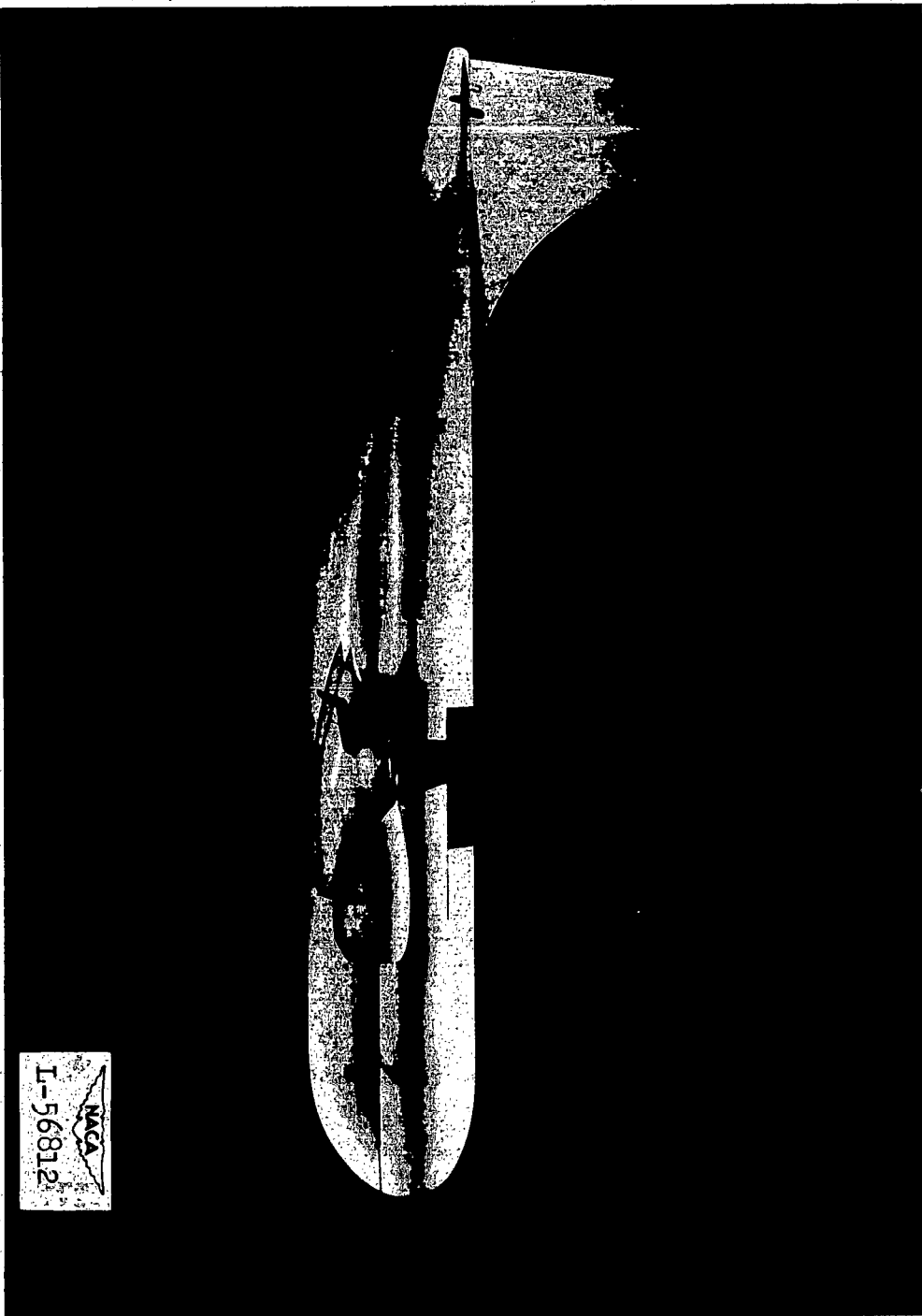
2000

NACA RM SL9116



(a) Front view.

Figure 2.- Model of the Boeing Stratocruiser.



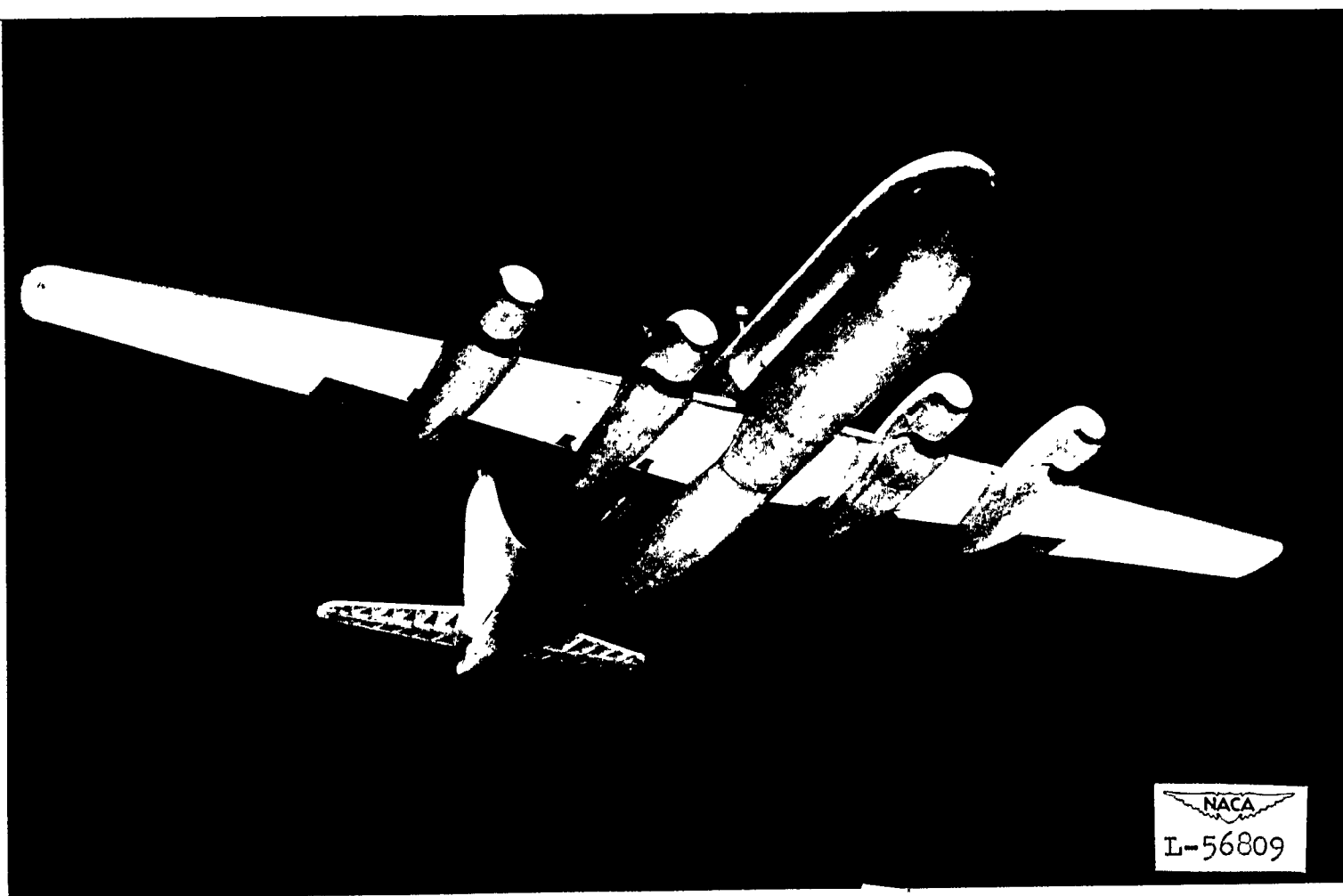
NACA
L-56812

(b) Side view.

Figure 2.- Continued.

254

NACA RM SL9116



(c) Three-quarter bottom view.

Figure 2.- Concluded.

2043

NACA RM SL9116

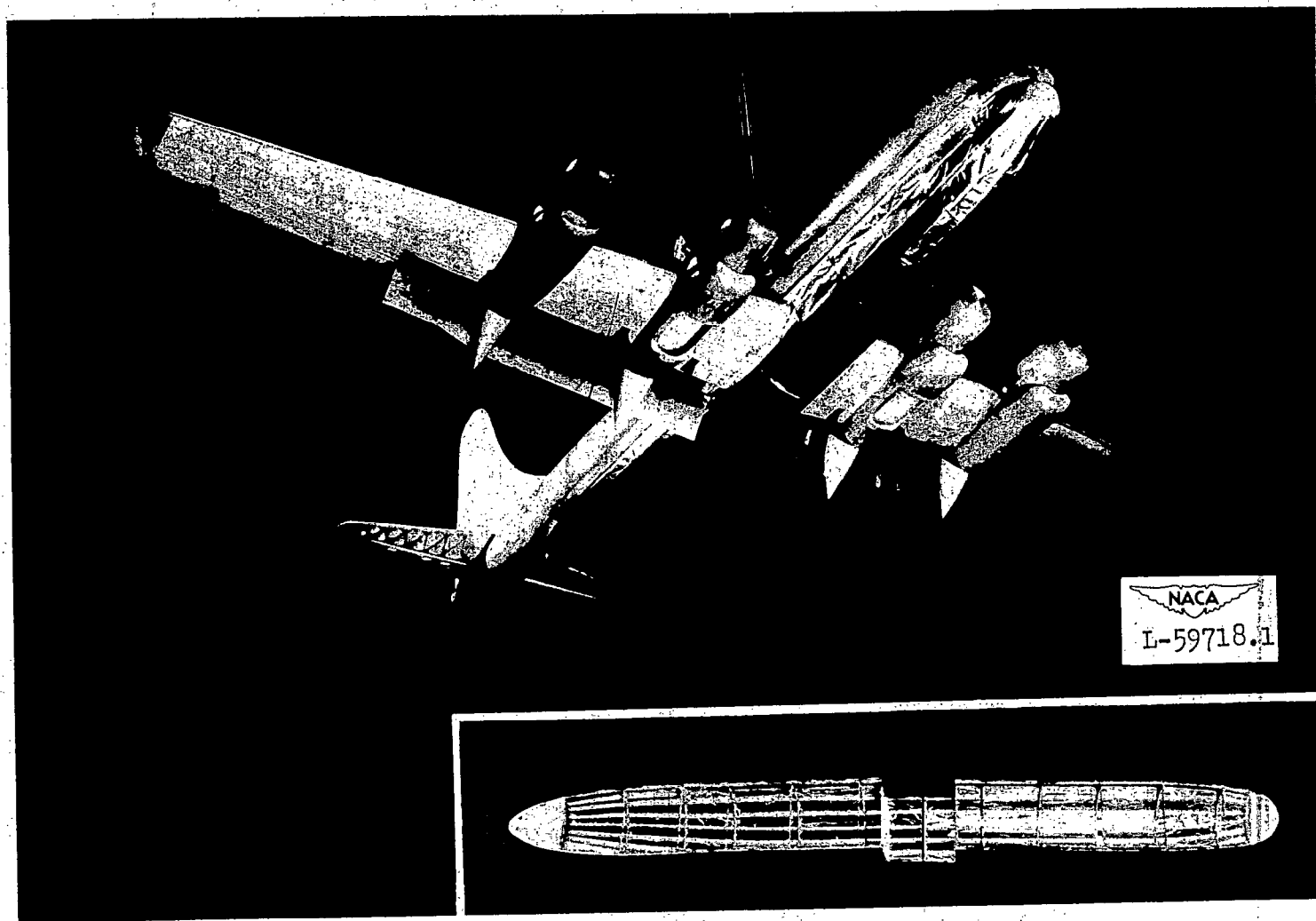
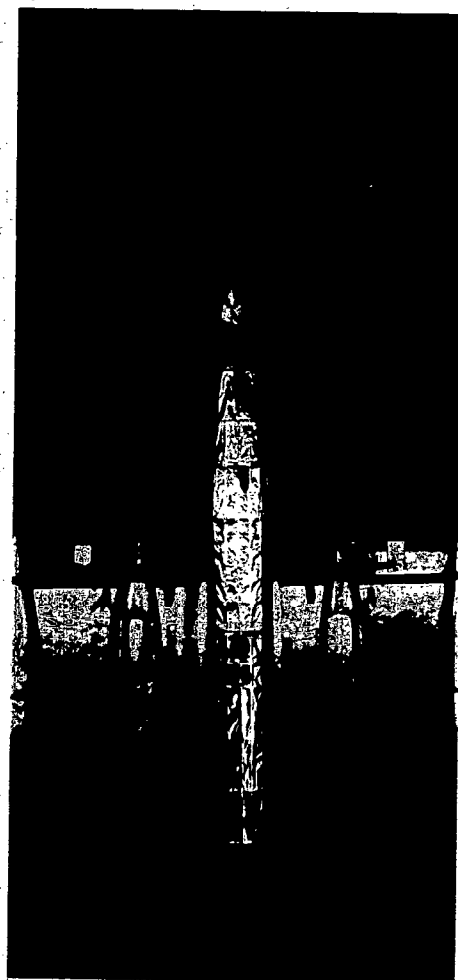


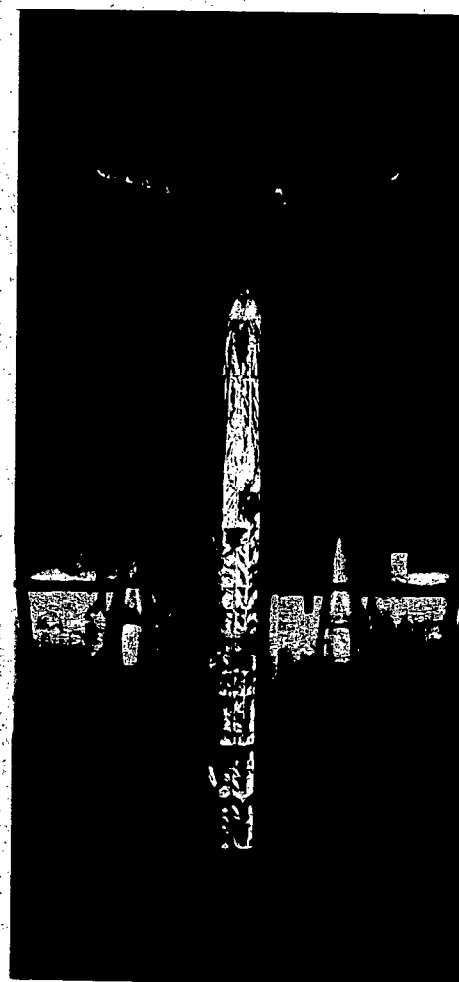
Figure 3.- Model with scale-strength bottom installed. Insert shows structure of scale-strength bottom.

254

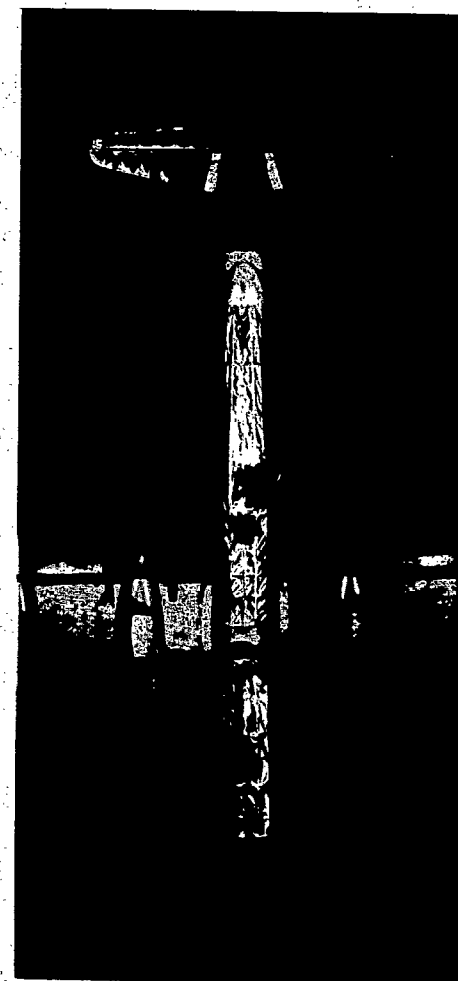
NACA RM SI 9116



(a) 9° attitude.



(b) 6° attitude.



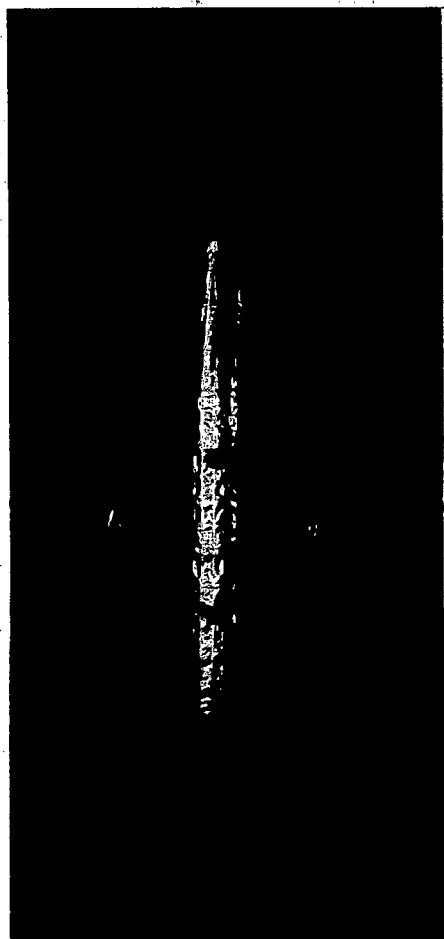
(c) 3° attitude.

Figure 4.- Damage sustained by a bottom scale strength of 8 pounds per square inch (full scale) at various landing attitudes with flaps full down.

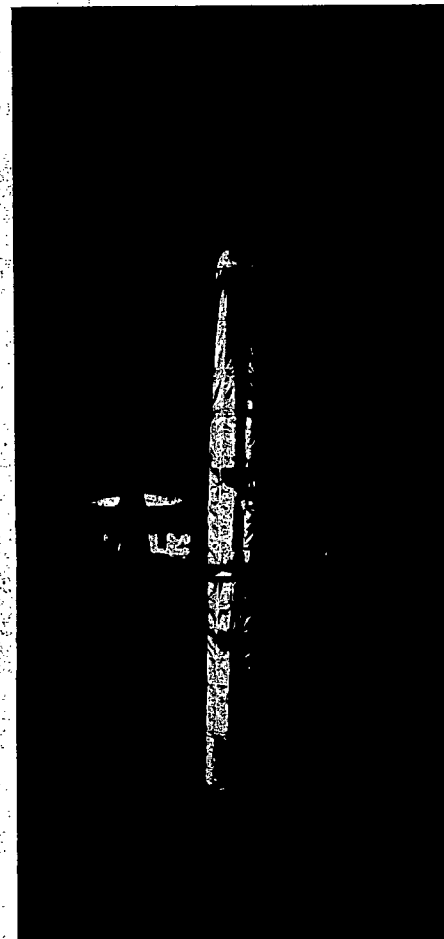
NACA
L-62124

244

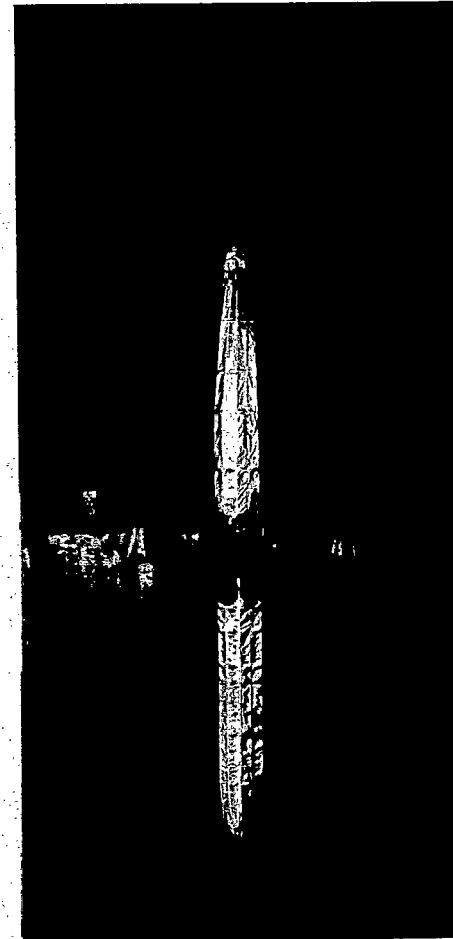
NACA RM SL9116



(a) 90° attitude.



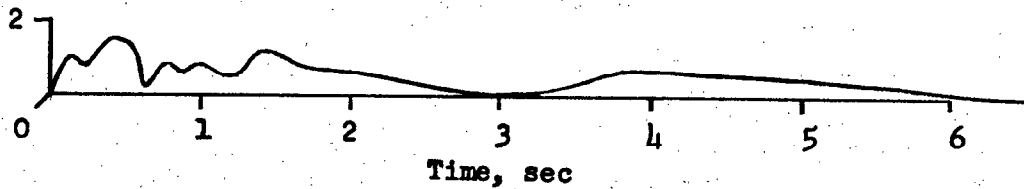
(b) 60° attitude.



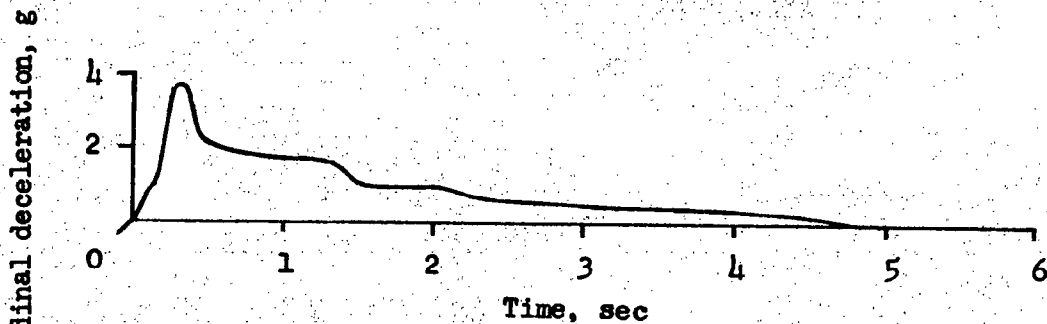
(c) 30° attitude.

NACA
L-62125

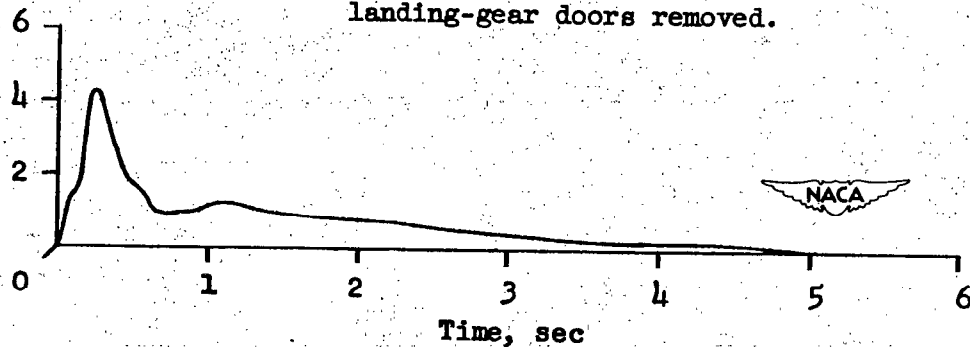
Figure 5.- Damage sustained by a bottom scale strength of 16 pounds per square inch (full scale) at various landing attitudes with flaps full down.



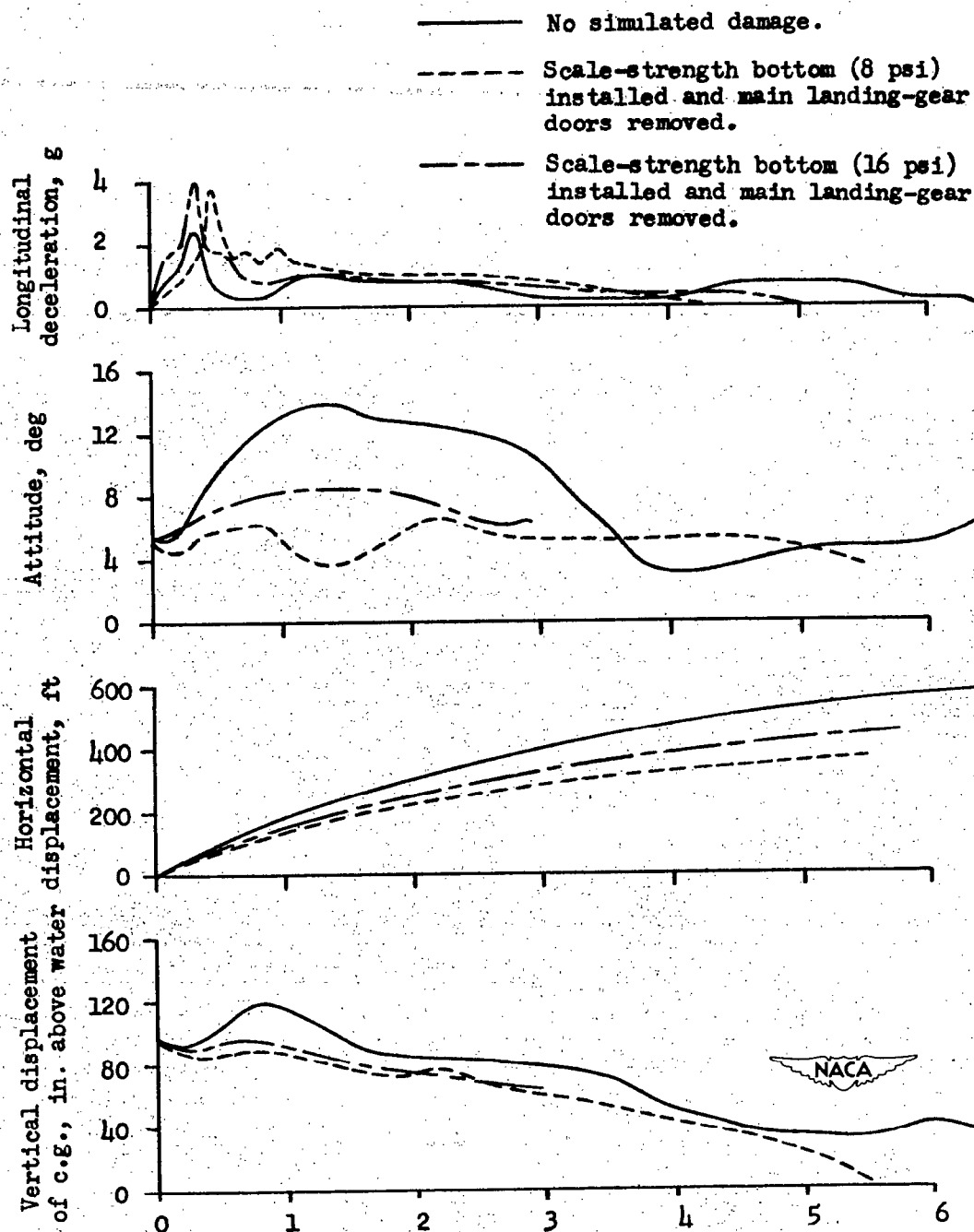
(a) No simulated damage.

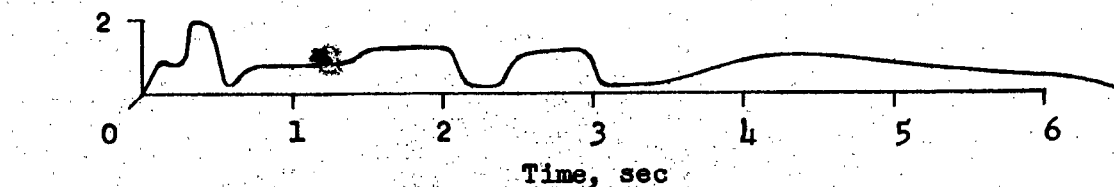


(b) Scale-strength bottom (8 psi) installed and main landing-gear doors removed.

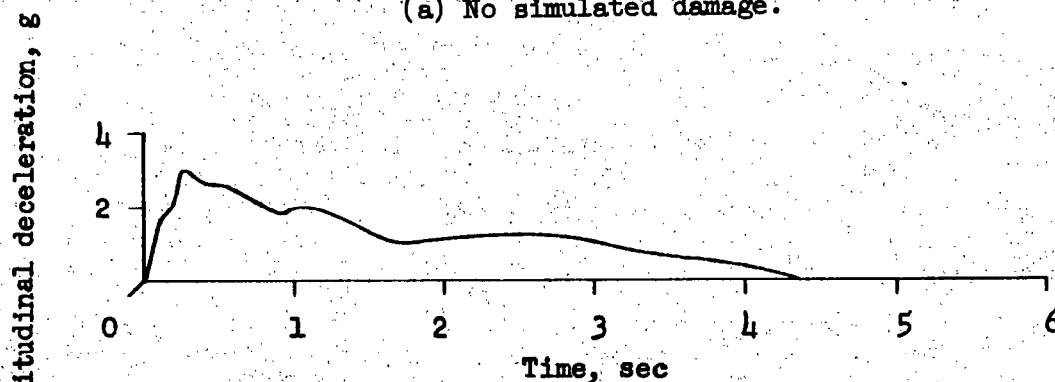


(c) Scale-strength bottom (10 psi) installed and main landing-gear doors removed.

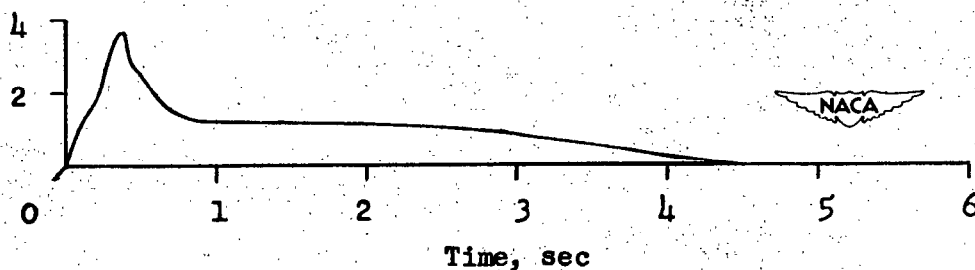




(a) No simulated damage.



(b) Scale-strength bottom (8 psi) installed and main landing-gear doors removed.

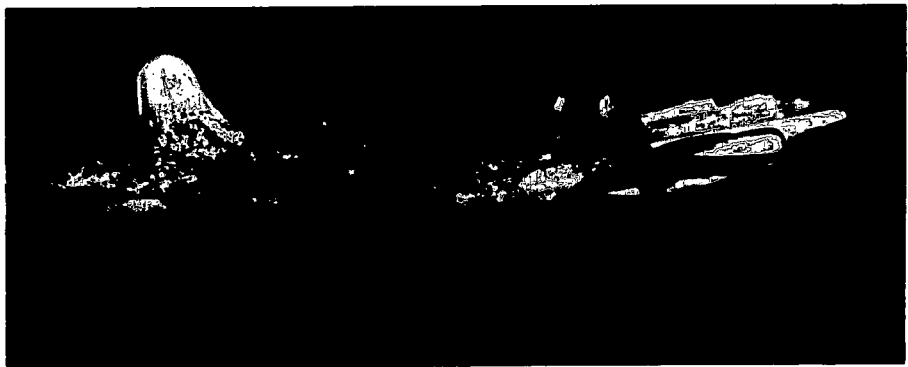


(c) Scale-strength bottom (16 psi) installed and main landing-gear doors removed.

Figure 8.- Longitudinal-deceleration curves landing attitude is 3° ; flaps are full down; landing speed is 126 miles per hour. (All values are full scale.)



Near contact



320 feet



386 feet

(a) Landing attitude 9° .

NACA
L-62126

Figure 9.- Sequence photographs with 16 pounds per square inch scale-strength bottoms installed and flaps full down. (All values are full scale.) Distances after contact indicated.

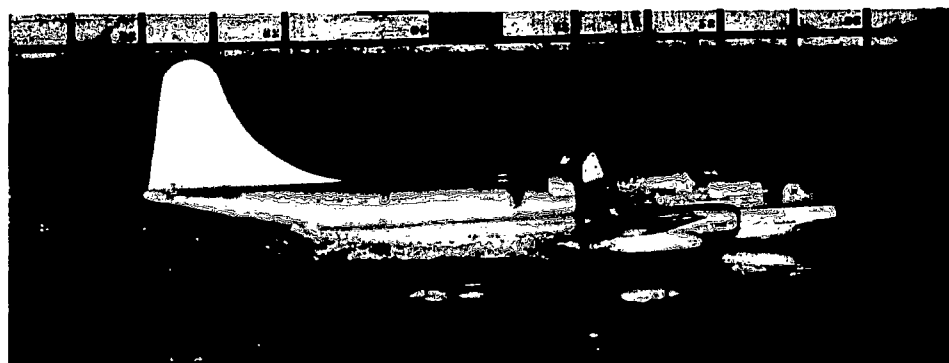
NACA RM SL9116



Near contact



320 feet



458 feet

(b) Landing attitude 6° .

NACA
L-62127

Figure 9.- Continued.

NACA RM SL9116



Near contact



160 feet



476 feet

(c) Landing attitude 3° .

NACA
L-62128

Figure 9.- Concluded.

NASA Technical Library



3 1176 01438 5364